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Pandemic as Game Mechanic: Simulation of Infection Spread for the Classroom.

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***Abstract*—In light of COVID-19, we created a novel simulation game, to explain exponential growth in disease spread. The simulation game is an open educational ressource (OER) for children to reflect on how test and isolation can be applied to stop contagious diseases. The game was reviewed in three classrooms (P3-P5) by a primary school teacher to pilot the applicability of the game in an educational setting. Based on qualitative feedback from pupils, we developed accompanying exercise sheets and website in close collaboration with the teacher.**

***Keywords*-Learning Games; Serious Games; Simulation Game; Game-Based Learning; Data Visualization; Data Literacy**

I. Introduction

With COVID-19 came an pandemic caused by exponential growth, the speed of which can be difficult to understand. Educational video games aim to induce motivation and provide players with learning outcomes [1]. In this paper, we describe our work towards teaching the complicated dynamics of disease spread to pupils in primary school (P3-P5). We created an educational video game which used a gas-model to simulate person-to-person disease spread. In the game, players had to develop a strategy to minimize the disease spread through test and isolation whilst awaiting the vaccine. Simulation is a genre which aims at providing virtual experiences, which replicate those in the real world [2]. When players finished playing the simulation, the game showed player performance in a timeline graph to facilitate reflection. Our contribution is two-fold, we describe : 1) a novel design of a simulation games for education. 2) data literacy needs and challenges associated with using graphs in games to facilitate reflection in the classroom. With Infection Detective, we hope further the larger effort of research around educating the public on the COVID pandemic and shed light onto underlying concepts behind new social restrictions people endure every day (e.g. social distancing, assembly thresholds, and testing).

II. Game Design

Infection Detective was designed around an agent-based simulation of infection spread (depicted in figure 1). The game focused on providing an experience of exponential disease spread. It contained seven levels, with increasing difficulty. Players moved the magnifying glass using the cursor or touch, across a map with walking people, represented by white dots (see Figure 1. The magnifying glass revealed whether the persons underneath it were infected or healthy and served as a metaphor for infection testing. Only 3-5 people fit within the magnifying glass and upon touch/click, infected people inside the magnifying glass get isolated. They moved off the map and inside an ambulance parked nearby.

The goal of Infection Detective was to use an isolation strategy to minimize disease spread until a vaccine has been found. Players won if they succeeded in their search for infected people and isolating them. At higher levels, the speed of spreading, and the population density increased, requiring refined search strategies. A blue progress bar indicated how much time was left before a vaccine was found. When enough time had passed, the progress bar was full and the player could proceed to the next level. Each level set upper limits for how many individuals could be infected. If the infection spread too much, the game ended, with an offer to try the level again.

Infection Detective employed a set of mechanics to make people engage with the topic of disease spread. Infection Detective did not mean to implement a full SEIR model. A number of real-world concepts such as immunity or death was therefore not part of the simulation. Instead, the disease spread in an agent-based fashion. Random agents were assigned the disease at start, and at fixed intervals diseased agents were then asked to locate agents around them in a radius and spread the disease to them. Players could expect that sick people may have spread the disease to anyone nearby, but the delay between their discovery and the disease spread, could mean it may have spread further. The game created time pressure on the player by manipulating how quickly the disease spread and imposed an upper limit on the

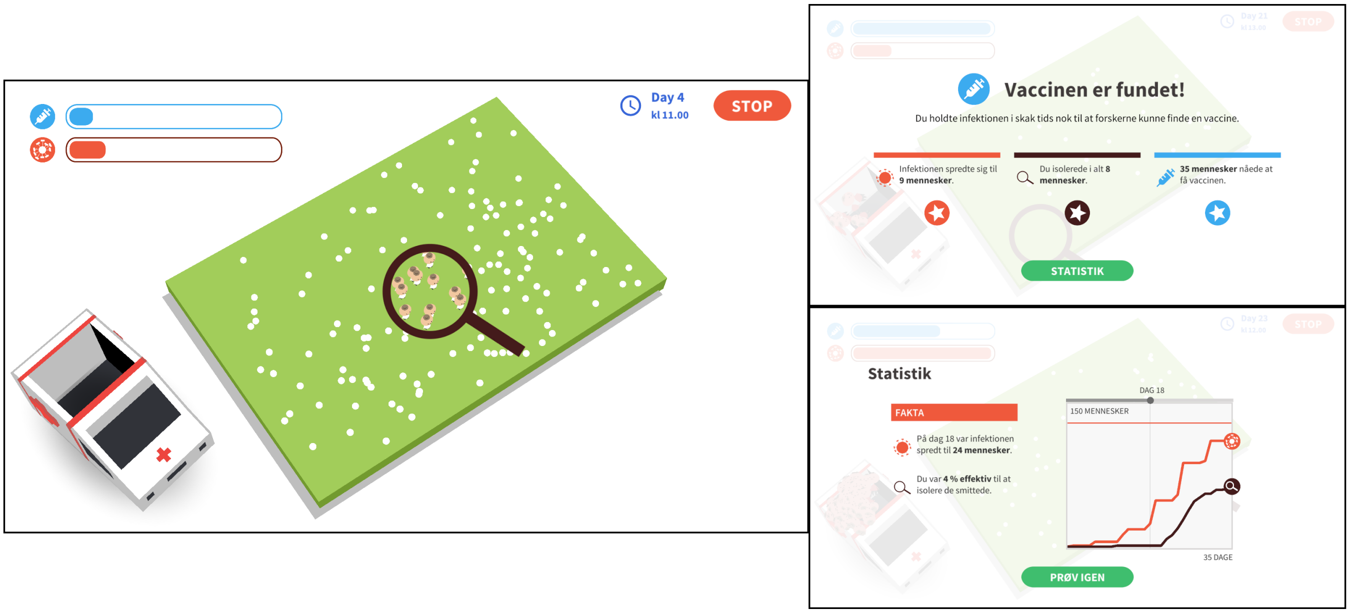

Figure 1. (Left) Players controlled the magnifying glass position with the mouse, which enlarged a given area on the green map. (Right Top) The results panel provided an overview of won/loss, and aggregate results (how many got infected, how many got isolated, how many managed to get the vaccine). (Right Bottom) Graph panel depicting infection spread over time (orange line) and isolation rate over time (brown line)..

total number of infected. red progress bar and the increasing number of cues added to the pressure. This required the player to find the most optimal testing strategy.

Infection Detective was designed to be a fast-paced game, designed around an input method which put your reflexes to a challenge. The benefit of using a fast pacing was that it kept people engaged in having something to do. Therefore, several design elements emphasized the fast passing of time. The in-game clock advanced by one day every 1.2 seconds. The arena typically contained 40 people represented as dots, which all walked in different directions with few breaks. A level typically ended after 25 seconds. The 12 levels could be played in five minutes, allowing for a high level of experimentation of how to complete the levels.

The magnifying glass was a metaphor for *test and isolation*. The game was intended for laptop use, and so the magnifying glass tests people on hover and isolated infected within the glass perimeter on click. For another example of using interaction work to convey a concept see the New York Times' 'An incalculable loss' that required users to scroll to experience the magnitude of 100.000 lives lost to Covid [3].

Regardless of whether the player lost or won, a results screen (Figure 1, Right Top) showed the player aggregated information from the play-through, in terms of total number of infected, total number of isolated, and total number of vaccinated people. After winning, the player's performance was graded by up to three stars - an orange star if the infection only spread to few people, a brown star if most infected people became isolated and a blue star if most people got vaccinated. This provided an overview of game performance. More in-depth information was provided by the statistics screen (Figure 1, Right Bottom). A graph provided time on the x-axis and quantity of people on the y-axis. A red line showed the development of the infection in the population, and a brown showing the number of people isolated. A red horizontal line marked the upper limit of how many people were present in total. The graph was partly interactive - moving the slider, updated the facts shown on the left-side. The graphs enticed players to reflect upon their performance, and allowed them to see the effectiveness of their isolation strategy. Players could then improve their strategy, and observe improvements not only from gameplay. The graph provided a more nuanced description of their performance.

III. Pilot Study

A primary school teacher conducted the experiment on-site with a P3, P4, and P5 class. Due to school policy, the classes' level of computer access differed. P3 had demonstrations, P4 used mobiles, tablets, and laptops, and P5 used laptops only. The teacher let the pupils play Infection Detective and listened to their questions and prompted them for feedback. The school gave consent to use anonymized quotations and opinions, which the teacher collected. An open-coding analysis identified themes in the teacher's qualitative feedback and levels of reflection according to Fleck and Fitzpatrick's model [4]: Reflective Description (e.g. a description of occured events, R1), Dialogic Reflection (e.g. looking for relationships between knowledge, R2), Transformative Reflection (e.g. leading to changes in practice, R3) and Critical Reflection (e.g. linking to social or ethical issues, R4).

IV. Results

In class P3, the pupils related the game to the recent COVID-19 outbreak (R2). Pupils from all classes recognized how easily you could become infected due to the spread speed of the infection. One pupil stated: "*If you don't think [the infection] is so important, you can use the game to understand how fast it can spread.*" (P3) Pupils related the infection spread to game difficulty: "*If the start [of the game] is bad, then it goes berserk. If you keep it (the disease) down, then it is easy.*" (P4) The pupils picked up on how social distancing plays a factor in the game (R2). "*The game shows that the infection spreads faster and faster, so it is important, if you get COVID-19, that you stay away from everybody else.*" (P4) "*[You can learn] how important it is to keep distance [to each other] [..]*" In class P4, pupils paid attention to how it was not possible to see who was infect, unless viewed under the magnifying glass (R1). "*Part of what I notice, is that you cannot see whether people are infected. I think it (the game) is trying to show that if one person has COVID-19 and does not know, and then he goes for a walk, then the disease spreads super fast. And then there are two who become infected, and they probably walk each their direction and then they infect others who also walk each their direction and infect more.*" The pupils in P5 pointed out elements in the game's narrative, which they did not believe related to reality (R2). "*It does not show how hard it can be for other people. It does not show that people are different. There is no reason to that they should go in an ambulance.*" (P5) "*You get isolated at home. It is only if things go bad, that you get sent to the hospital.*" (P5)

Infection Detective required high level of teacher control, if the pupils were to reflect on the outcomes. The teacher was concerned that the text would require well developed reading skills, considering the age. Several pupils from P5 class described that they did not read the text and graphs shown after the game. "*I just press [the] next [button] - like I always do.*" 6 of 26 answered that they had read the text, while 16 of 26 answered they had tried to read the graph. The teacher judged that the graphs could be useful to compare with infection spread in the real world, but on their own would be insufficient for the pupils to understand the results, unless they had well developed reading abilities. The teacher suggested that Infection Detective could be assigned to pupils as homework with a follow-up discussion about the game as a model for infection spread. Models have strengths and weaknesses and the pupils can learn from identifying fallacies in the model's underlying assumptions.

V. Discussion and Conclusion

Few comments from the pupils related their test strategy. The pupils described the notion of a *good* start and a *bad* start, as if it was down to luck. It remained unclear whether the results shown after a lost game had the desired effect to adjust the pupils' subsequent test strategies. Many of the pupils explained that they did not make use of the graph and the text annotations next to the graph.

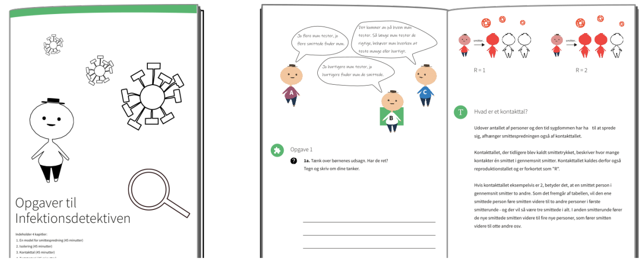

Figure 2. The accompanying exercise sheets (25 pages).

Further collaboration with the teacher resulted in the creation of exercise sheets for print, which teachers can use to prompt the pupils to try alternative strategies of and describe the changes they see in the graph (see Figure 2). The teacher wanted to utilize Infection Detective to teach terminology such as isolation, testing strategy, and the basic reproductive number. The exercise sheets required classic written work while the game provided an environment for experimentation. Initially the game defined rules and became a motivator for the pupils. Later the game became a platform to try different test strategies and let pupils reflect on their experiences.

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References

[1] C. Linehan, B. Kirman, S. Lawson, and G. Chan, "Practical, appropriate, empirically-validated guidelines for designing educational games," in *Proc. of CHI'11*. ACM, May 2011, p. 1979–1988.

[2] E. A. Boyle, T. Hainey, T. M. Connolly, G. Gray, J. Earp, M. Ott, T. Lim, M. Ninaus, C. Ribeiro, and J. Pereira, "An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games," *Computers and Education*, vol. 94, p. 178–192, Mar 2016.

[3] D. Barry, L. Buchanan, C. Cargill, A. Daniel, A. Delaquérière, L. Gamio, G. Gianordoli, R. Harris, B. Harvey, J. Haskins, and et al., "Remembering the 100,000 lives lost to coronavirus in america," *The New York Times*, May 2020. [Online]. Available: https://www.nytimes.com/interactive/2020/05/24/us/us-coronavirus-deaths-100000.html

[4] R. Fleck and G. Fitzpatrick, "Reflecting on reflection: framing a design landscape," in *Proc. of OZCHI'10*. ACM, Nov 2010, p. 216–223.